5.0 SAFETY POLICIES AND REQUIREMENTS

Astrotech has strict safety policies and operating requirements for the use of its facility and support equipment. This section begins with a discussion of overall management policies and requirements (Section 5.1), describes operation and maintenance requirements (Section 5.2), and concludes with specific personnel training requirements (Section 5.3).

Because Astrotech only provides the use of the facility and limited support equipment to their customers and performs no hands-on processing of a spacecraft, Astrotech requires that customers provide detailed technical data and supply operating procedures for all hazardous equipment and operations. Astrotech's schedule for submissions, allowing time for review and approval prior to initiating operations, is outlined below (see Section 5.1.1). Additional requirements include such things as training and certification of propulsion teams, scheduling and coordinating of all hazardous operations through Astrotech, and safety monitoring by Astrotech and the customer of all hazardous operations scheduled to take place for a specific spacecraft.

When hazardous equipment or operations have been or are to be used at KSC or CCAFS, the customer's detailed technical data and operating procedures are also reviewed and approved by NASA and/or the Air Force. The general safety standards against which these plans and procedures are scrutinized are Air Force Regulation AFR 127-100 Explosive Safety Standards, Eastern Space and Missile Center Regulation ESMCR 127-1 Range Safety documents and Kennedy Space Center safety requirement documents KHB 1700.7 and KHB 1710.2. The responsibilities of all parties involved in the processing of a payload at ESMC are detailed in ESMCR 127-1. The safety evaluation team compared Astrotech's safety policies and procedures to these requirements for Government facilities.

Further, the safety of operations at the Astrotech facilities is a partnership between Astrotech and its customers and each has compelling financial incentives to maintain the highest standards of safety during payload processing operations. The customer is bringing in a satellite that may be worth in excess of $100 million. At the same time, Astrotech has an investment of approximately $15 to $20 million in the facilities and facilities support equipment which it must protect. In addition Astrotech wants to maintain its ability to process payloads to ensure future business and revenues.

Astrotech also commissioned detailed technical analyses, both before the initial facility construction and before the facility modifications. These safety analyses are discussed in Section 7.1.1.

5.1 Management Policies and Requirements

The document Safety Policy prepared by Astrotech delineates corporate policy regarding desired levels of safety and the safety criteria against which the customers' hazardous operations safety plan are assessed. It outlines the documentation required of customers to meet Astrotech's safety requirements for customer required support equipment, operating procedures, and personnel certification and training; safety requirements for performing payload operations including ordnance checkout and installation, propellant loading, meteorologic baseline conditions for conducting operations, allowable hazardous atmosphere work levels (25% LEL)[1]; safety requirements for handling, lifting and transporting spacecraft; and accident reporting requirements.

5.1.1 Documentation Requirements

Astrotech requires certain documentation from its customers to ensure that its own safety criteria and standards are met. These include:

•At least 90 days prior to processing, data on flight hardware and safety critical subsystems, an operations schedule, a list of technical operating procedures and designation of whether hazardous or not, and a list of safety and emergency equipment and procedures;

•Certification that each individual performing operations has been trained and certified, if appropriate, and is medically able to perform assigned hazardous tasks;

•At least 30 days prior to processing, detailed step-by-step procedures for hazardous operations; and

•Any necessary federal and state licenses to handle radiation sources, data on the sources, and documentation on testing, packaging, transport and transfer of the sources.

The customer must comply with all Astrotech safety requirements or request a waiver from Astrotech, detailing what system or equipment is involved, why a waiver is being sought, any potential hazards created and rationale for acceptance. No waivers have been requested as of August 1990. Astrotech will then either approve or deny the waiver. The customer is also responsible for obtaining any waivers or variances from federal regulation and must provide these to Astrotech.

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[1] 25% of the Lower Explosive Limit (LEL). The LEL is the volume percent concentration of a flammable material in air at which the material will ignite, propagate flame, and in a confined area an explosion can occur. Using 25% of the LEL provides a four-to-one margin of safety.

5.1.2 Safety Requirements

Written operating procedures are required for all hazardous operations that are performed at the Astrotech facility and are reviewed and approved by Astrotech prior to the operations. Simultaneous hazardous operations in the same hazard control area are prohibited. Joint safety inspections by both Astrotech and customer safety representatives are generally performed prior to and immediately after payload and ground support equipment installation at the facility, before initiation of hazardous operations, and after any modification to the facilities or equipment. Specific requirements are identified below for:

- Payload and ground support equipment
- Environmental conditions
- Handling and transport

Payload and Ground Support Equipment

Propellant systems and systems ground support equipment (usually provided by the customer) must meet the requirements of either Air Force Manual AFM 127/161 or Kennedy Space Center Handbooks KHB 1700.7 and KHB 1710.2. These requirements are outlined in the Astrotech safety policy handbook[2] and apply to all operations at Astrotech. Before any new, modified or repaired propellant subsystems, storage or transport systems can be used at the Astrotech facility, the customer must validate and certify that they meet the requirements. Materials used in propellant systems must meet compatibility and use standards as detailed in either AFM 161-30 "Chemical Rocket Hazards," Volume II, or the CPIA Publication Number 194, "Chemical Rocket and Propellant Hazards," Volume III. A leak check using a helium leak detector is performed on load lines, pressure lines and transfer systems prior to beginning propellant loading operations to ensure equipment integrity before introducing propellant.

In Astrotech's Safety Policy, specific requirements are detailed for standards that must be met by electrical equipment, electrical equipment in hazardous atmosphere areas, grounding and bonding, and maintenance operations. These are designed specifically to preclude hazardous conditions and include detailed requirements such as hazardous area distances for flammable liquid propellants, and instructions for "explosion-proofing" of electrical equipment operated during pressurization or flow of flammable propellants.

Pressure systems (e.g., pneumatic and hydraulic systems), that contain fluids above ambient pressure and include components like tanks, pipelines, gauges, fittings, valves, regulators, and relief devices are also closely scrutinized by Astrotech. Such

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[2] Safety Policy, Astrotech International Corporation, Sections 3.2.6.1-3.2.6.3.

things as pressure vessel American Society of Mechanical Engineers (ASME) design and marking requirements, safety factors for burst design of components, and system operating relief pressures and flow capacities are indicated. Flexible hoses, and inspection, calibration and test requirements are also discussed.

Radiation is also addressed in the safety requirements. This covers both ionizing (radioactive) radiation and non-ionizing (microwave, radio frequency, optical or laser) radiation sources. General requirements for preventing inadvertent personnel exposure, assuring fail-safe operations, and testing and maintaining equipment are outlined. As discussed in Section 4.3.5, the only use of ionizing radiation at the facility is for limited leak checks of equipment by one customer.

A significant component of the payload/ground support equipment safety requirements deals specifically with solid rocket motors, ordnance (electro-explosive devices used in destruct and separation systems) and liquid propellants, since these are considered hazardous materials and any operations involving them are closely and carefully scrutinized.[3] Other hazardous materials are also mentioned including cleaning solvents and adhesives because of potential flammability or reactivity. Astrotech is also concerned with the toxicity of the propellants and has installed a containment system to prevent releases to the environment. The system is described in more detail in Section 4.4.1.

Environmental Conditions

The major concerns addressed here are ensuring the proper meteorological conditions are adhered to in scheduling and conducting propellant handling and loading operations. No hazardous operations may be initiated if electrical storms are within five miles of the facility or if hurricanes are predicted; if operations are ongoing, safety personnel are notified of any thunderstorm activity within 25 nautical miles.

A hazardous indoor atmosphere is defined (25% of the LEL) for sampling purposes as well as a level for personnel (oxygen between 19.5 and 25% by volume) activity. This requirement assures at least a four-fold safety factor for fires because the LEL is the minimum vapor concentration at which a compound can ignite.

Handling, Transport and Storage

Requirements for hoists, slings and cranes, including safety factors and load test requirements, test frequency, and inspection details for each type of lifting equipment are

[3] Safety Policy, Astrotech International Corporation, Section 3.2.

outlined; compliance with applicable OSHA 29 CFR and American National Standards Institute (ANSI) B30 sections is required[4]. Transport of fueled spacecraft to the launch pad is not allowed to begin when electrical storms are within five miles, and general vehicle and safety system checks are required prior to embarking.

Astrotech requires SRMs to be handled and stored in accordance with the requirements of their hazard classification and storage compatibility group. The storage compatibility group is the group for explosives, propellants or other hazardous materials which can be stored together without significantly increasing the probability of accident, or for a given quantity, the magnitude of the effects of such an accident. The compatibility groups are based on the system recommended for international use by the United Nations (UN) as adopted by the DoD. The hazard classification system is also based on the recommended UN international system and distinguishes between mass-detonating and non mass-detonating explosives (including propellants)[5].

All explosive materials used at Astrotech are required to be stored, inspected and tested in approved areas only and in accordance with the hazard classification and storage compatibility grouping of the material. Ordnance must be stored in the high bay ordnance lockers (Hoffman boxes), and work on Category A[6] EEDs must be performed only in Building 2. Work on Category B[7] EEDs requires a 20 foot clear area.

Ordnance and associated flight items are required to be the natural color of the devise, while non-flight items require color coding and submittal of the coding key to Astrotech. The color code facilitates efficient operations.

Generally, all liquid propellants are transported to the Astrotech facility from CCAFS by Astrotech personnel in DOT-approved transport containers. A maximum of one cylinder (approximately 3,600 pounds) of nitrogen tetroxide or two 55-gallon drums of fuel (approximately 925 pounds of anhydrous hydrazine or approximately 800 pounds of monomethyl hydrazine) is allowed in any one shipment. On occasions when it is necessary to load propellant into the propellant carts from the bulk

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[4] Ibid. Section 3.4.1.

[5] Hazards of Chemical Rockets and Propellants, Volume II, Solid Propellants and Ingredients, C.P.A. Publication 394, September 1984.

[6] Category A EEDs are those which by the expenditure of their own energy, or because they initiate a chain of events, may cause injury or death to people or damage to property. ESMCR 127-1, 30 July 1984, Attachment 1.

[7] Category B EEDs are those which will not, in themselves, or by initiating a chain of events, cause injury to people or damage to property. ESMCR 127-1, 30 July 1984, Attachment 1.

storage facility, the carts are transported to Astrotech under the protection of a security escort and in accordance with the applicable DOT transport approval. Transport of fuel and oxidizer never occurs at the same time.

Liquid propellants are present at the Astrotech facility only as long as required to condition, sample, load the liquid fuel or oxidizer into the spacecraft, and transport the spacecraft to the launch pad. No liquid propellants are stored at the Astrotech facility. Liquid propellants brought on site are placed in Building 2 either on a fueling island or in a propellant cart storage room, where they are conditioned with helium for 5-7 days until fully saturated. This saturation is done to ensure that adequate pressure is maintained in the spacecraft propellant tanks. Vapor detectors, which alarm directly to the guard house, are used whenever liquid propellants are on site so that any leaks will be detected immediately.

Only enough liquid propellant is brought on site for loading the payload with allowance for ullage in the storage cart and sampling. Following completion of a fueling operation, any residual propellant is drummed appropriately and returned to CCAFS for reuse or disposal. A maximum of three nearly empty drums, containing small amounts of residual fuel, can be transported at one time.

After nitrogen tetroxide is loaded into a spacecraft, the micropore filter used for its transfer is contaminated with a small amount of nitrogen tetroxide. This is removed using freon, which is planned to be distilled in a closed-loop distillation system. After the small amount of oxidizer in the freon has been neutralized, the contaminated freon is run through the unit which recovers the freon for reuse. Because the closed-loop distillation system has not yet been installed, the cleaning solution, which is classified as "waste oxidizer" and is 99% freon, is currently drummed and treated as a hazardous waste according to EPA regulations.[8] Any other residual chemicals classified as hazardous waste are shipped off site to an EPA approved Treatment, Storage, and Disposal facility within 90 days of their generation. During six years of operation, only one drum of hazardous waste has been generated that required off-site disposal.

The largest propellant transfer operation to take place at the Astrotech facility occurred in 1990 with the processing of INTELSAT. Approximately 4,000 pounds of oxidizer and 2,400 pounds of fuel were loaded into the spacecraft. Payloads of this size are rare, and typical payloads are somewhat smaller, generally requiring about 1,000-1,500 pounds of propellants (fuel

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[8] Resource Conservation and Recovery Act (RCRA), Subtitle C, 40 Code of Federal Regulations (CFR), Part 262 - Regulations Applicable to Generators of Hazardous Waste.

and oxidizer) to be brought on site at any one time, depending on the requirements of the spacecraft. This typical liquid propellant quantity on site is about twenty percent of Astrotech's design criteria and DER permit allow; 5,000 pounds of oxidizer and 2,500 pounds of fuel. These maximum permitted quantities are 240-650 times less than the amount of propellants used to fuel a Titan ELV at CCAFS.

5.1.3 Accident Reporting

In the event of an accident, Astrotech has established reporting requirements so that it can evaluate accident causes and initiate preventative measures. All customers are required by Astrotech to prepare a formal written report of any accident involving serious injury or death to personnel or substantial damage to equipment or facilities within five working days. Minor incidents can be reported verbally; however, minor incidents with high accident potential must be formally reported. In over six years of operations, there have been no accidents requiring formal accident reporting. In addition, Astrotech is subject to accident reporting requirements under SARA Title III and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as outlined in Section 6.4.

5.1.4 Insurance Inspections

An additional external safety inspection is performed by an inspector representing Astrotech's insurance company to ensure that the facilities meet the insurance company's safety standards. Prior to entering into a contract with Astrotech, each potential customer may have an agent representing his insurance carrier inspect the facilities to ensure that his own safety and operating standards are met. The inspections are performed approximately twice a year.

5.2 Operation and Maintenance Requirements

Astrotech provides continuous safety monitoring during all hazardous operations by the Safety Officer and he is empowered to stop an operation if he deems it unsafe or problems are indicated. Most hazardous operations can be completed in one 8 hour shift and that shift is scheduled during normal business hours to maximize personnel alertness. At least one shift separates operations involving fuel and operations involving oxidizer, during which time the trench drain system is flushed and reconfigured to prevent any possibility of contact between fuel and oxidizer.

Safety procedures and plans for all hazardous operations must be submitted by the customer to Astrotech for review and approval. In addition, Astrotech regularly inspects and tests all equipment that it provides. As detailed below for specific equipment, the daily visual checks are common as are semi-annual to annual system-wide verifications.

There are three Astrotech safety personnel who are always available to respond to incidents or accidents during critical periods of handling SRMs, ordnance or liquid propellants. They all have pagers and can be reached at anytime during the day or night. All three individuals are intimately familiar with payload processing operations and have worked at Astrotech since the facility opened. If a problem arises after work hours, the guard has a full set of notification procedures to follow, that include calling the appropriate Astrotech personnel.

Personnel safety equipment (e.g., static dissipating devices, safety glasses for EEDs or propellant grain inspection, gloves and cartridge respirators) supplied by the customer must be approved by Astrotech. Astrotech provides personal protective equipment (see Section 4.4.3), flame retardant coveralls, legstats, emergency escape units with a 5-minute air supply, and Scott air packs with a 30-minute air supply. See Section 4.4.3.

Overhead cranes and hoists are inspected prior to use each shift visually and by activating the pendant emergency power kill switch under simulated load conditions. All cranes, hoists and hooks are proof tested at least yearly at 125% of their rated load per OSHA requirements (29 CFR 1910) and ANSI B30. All hooks are magnafluxed yearly. Proof load data are attached to each crane pendant. Transfer of spacecraft from high bay to high bay in Building 2 entails the use of the Javelin feature on the overhead crane, and is only performed by fully trained Astrotech personnel[9]. The roll-up doors in Building 2 are also restricted to operation by Astrotech personnel.

The conductive floors of Building 2 are checked at least annually by Astrotech per NFPA 56A to verify that the static dissipation capacity is 1 Megohm or less. This safety check ensures continuing dissipation of any electrical sparks. Equipment is bonded or grounded when attached to any device containing hazardous materials. Grounding straps are inspected prior to use and daily when in use, and if the integrity of the cable is suspect for any reason, the cable is checked to ensure proper functioning (e.g., a resistance of less than 10 ohms).

Prior to beginning operations, area safety checks are performed by both Astrotech and the customer, if ordnance, solid motor or liquid propellant are present. Each shift that propellants are on-site, toxic vapor checks (sniff checks) are made and the results marked on the high bay door. Once propellants have been brought into Building 2, continuous monitoring using the MDA toxic gas detectors is performed. See Section 4.4.1.

Fire protection equipment in Building 2 is checked visually at the start of each shift. The entire system is tested on a semi-

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[9] Safety Standard Operating Procedure 1988, Astrotech Space Operations, L.P., pp 11-14.

annual basis (every 5 to 7 months depending upon operational schedules). See Section 4.4.4 for a more detailed description of the fire protection system.

Security is provided for the high bays by key and cipher control available only to the customer and Astrotech. The cipher control may be changed at any time interval specified by the customer.

5.3 Personnel Training Requirements

The Astrotech Safety Officer is responsible for ensuring that Astrotech employees have adequate training in dealing with hazardous materials. Employees who have responsibility for handling hazardous materials, and who are assigned to response duties, have training equivalent to that required by NASA personnel who perform similar duties at KSC. This training exceeds the requirements of Training Standards for Hazardous Technicians Level III and Level IV as designated under OSHA, Title 29 CFR Section 1910 and EPA, Title 40 CFR Part III, and applicable to a wide variety of industries that use hazardous materials.

Customer personnel coming to Astrotech, who participate in hazardous operations (e.g., propulsion teams), must each have certification from the employer noting the individual's training and qualification as well as physical fitness for his assigned hazardous task. Astrotech provides safety briefings for customer employees that include:

- NASA propellant handling safety video
- Facility specific safety/emergency features
- Safe operating procedures and checklists
- Safeguards and safety devices
- Personal protective equipment
- Monitoring and warning devices
- Emergency and contingency procedures

After such training, customer personnel are familiarized with the Astrotech facility and prepared to implement the safety procedures effectively.